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PAPERS ON CEREAL AND FORAGE INSECTS.

THE SLENDER SEED-CORN GROUND-BEETLE.

BY

W. J. PHILLIPS,
Agent and Expert.

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(*Clivina impressifrons* Lec.)

By W. J. Phillips,
Agent and Expert.

INTRODUCTION.

Observations have been carried on for several years in the vicinity of New Paris, Ohio, on an interesting little beetle known as the "slender seed-corn ground-beetle" (*Clivina impressifrons* Lec.). As much new information has been secured regarding its early development, and since it is probably responsible for some of the injuries charged up to other insects, it has been thought advisable to make it the subject of a short paper. As it works below ground, in the kernels of corn, and confines itself to swampy, peaty soils, the farmer is likely to believe that the seed fails to germinate and to attribute the cause to excessive moisture, cool weather, and inferior seed, never dreaming that this modest little creature is busily collecting his toll, sometimes as many as fifteen or twenty individuals being found in or about a single hill.

The writer wishes to acknowledge his indebtedness to Prof. F. M. Webster, under whose direction this work was carried out. To the patient and untiring efforts of Mr. V. L. Wildermuth we owe the information herein presented concerning the habits of the larvæ and pupæ. The writer, having previously planned the work, carried on observations on the adults and their economic relations, and is responsible for the descriptive matter. Acknowledgments are due Mr. Frederick Knab for helpful suggestions in the preparation of descriptions.

DISTRIBUTION.

The slender seed-corn ground-beetle belongs to a very large genus, there being over two hundred species, distributed throughout the entire world, with the exception of the extreme northern and southern latitudes. The genus as a whole is supposed to be carnivorous. The species under discussion is a native of the eastern United States and is the only one on record as being a plant feeder. Doctor Le Conte described the species in 1884 and gave New York as its habitat. Since that time it has been found in Canada, New Jersey, Ohio, Indiana, Illinois, Iowa, and Kansas.

DESCRIPTIONS AND LIFE-HISTORY NOTES.

THE EGG (fig. 8, *a*).

A correct description of the egg can not be given, as all those observed are from dissections and have not retained their normal shape. They are a little over 1 millimeter in length and over one-half millimeter thick, obtusely rounded at ends. The chorion is minutely reticulate. In color they are a delicate white. It is probable that they are deposited somewhere below the surface of the soil, as the larvæ are blind and are found quite deep in the earth. Nothing is known relative to the period of incubation, as the eggs have never been found in the fields. Numbers of adult females were dissected and none contained more than three to four mature eggs, but they could be found by this method from early spring on throughout the entire summer.

THE LARVA (fig. 8, *b*, *e*, *f*).

Following is a detailed description of the larva:

Color: Head and prothoracic plates dark brown, plates of the other two thoracic segments much lighter; cerci and anal tube brown, somewhat dusky at the tips; abdominal segments pale yellowish; tips of mandibles black; legs dusky. Just after molting the larva is a delicate creamy white.

Form: Depressed fusiform; breadth greatest at about the fourth abdominal segment; length a little over six times the greatest breadth; thoracic segments narrower than the abdominal ones.

Head quadrate, depressed dorsally, with a deep, broad furrow starting at the base of the antennæ and extending in a posterior direction, gradually fading out; epistomal sutures joining near the base of the head; a deep impression on each side of the head, near the base, extending beneath and then anteriorly to base of mandibles; on the dorsal surface there is a chitinous ridge at the base of the antennæ.

Ocelli absent.

Epistoma reaching posteriorly about three-fourths of the distance from the front of the clypeus to the occipital foramen, its lateral sutures sinuate; frontal angles obtuse, rounded.

Clypeus fused with the epistoma. Labrum bilobate, with deeply serrated margin.

Setæ: Dorsally there is one large and one small seta immediately at the base of the mandibles; a large seta on each side near the margin of the epistomal area, posterior to the antennæ; several small setæ on the clypeal and epistomal areas; a large seta and several smaller ones near the center of the frontal angles; two large setæ and several small setæ on the lateral margin of the head; one large seta near the base and slightly ventral of the antenna; a small seta ventral of this last one; numerous medium-sized setæ on the ventral aspect.

Antennæ four-jointed; first two joints clavate-cylindrical, joint 2 four-fifths as long as joint 1 and at the base about three-fourths as thick; joint 3 broadly clavate and about one-third longer than joint 2, its outer angle truncate and bearing a prominent acorn-shaped appendix; joint 4 slender, cylindrical, and slightly pointed at the extremity; joint 3 with two large setæ toward the apex, one on the outer and one on the inner margin, and one on the dorsal face near the base; joint 4 with three large and two small setæ at the distal extremity.

Mandibles falcate, slender in front of the retinaculum, apparently smooth; retinaculum much nearer the base than the tip, small, directed slightly backward; a medium-sized seta on the outer margin of the mandible near the base.

Maxillæ: Maxillary stipes obconical, about 3.6 times longer than wide at its widest point, slightly curved; two large setæ on the outer and one on the inner margin near the distal extremity. Outer lobe probably slightly surpassing the first joint of the palpus; joint 1 clavate, with small seta on inner distal margin, about five-eighths as long and one-half as broad as joint 1 of the palpus; joint 2 slender, conical, and fully as long as joint 1. Inner lobe conical, short and inconspicuous, a large seta at its base Palpigerous stipes about three-sevenths as long as joint 1 of the palpus, and larger; joint 1 slightly clavate, about three times as long as broad; joint 2 apparently cylindrical, not quite half as long as joint 1 and about one-half as broad; joint 3 conical, small, about two-thirds as long as joint 2.

Labium: Mentum almost quadrate, slightly convex, smooth, much narrower at the proximal than at the distal end, slightly longer than broad at its broadest point; just

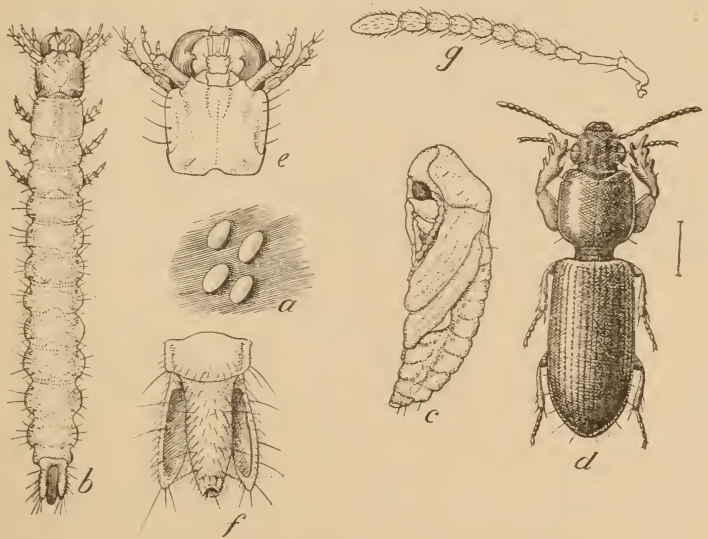

FIG. 8.—The slender seed-corn ground-beetle (*Clivina impressifrons*): *a*, Egg; *b*, larva; *c*, pupa; *d*, adult; *e*, ventral view of larval head; *f*, ventral view of anal segment; *g*, antenna. All much enlarged. (Original.)

below the insertion of the palpi is a large seta; quite hairy except on the ventral surface; ventral surface with a very slight groove down the center; on either side of the labium are three or four very large setæ, probably arising at its base; joint 1 of the palpus slightly constricted near the base, the distal end the largest, little longer and about the same width as joint 1 of maxillary palpus; joint 2 conical, and nearly as long as the two distal joints of the maxillary palpus; the stipes are slight elevations of the mentum, having no distinct outline. Ligula minute, nearly quadrate, nearly as long as joint 1 of the palpus and bearing two small setæ.

Thorax: Prothorax nearly as long as mesothorax and metathorax combined; plates much more strongly chitinized; a slight impression on each side near the anterior extremity; two large setæ on each lateral surface; one large seta on the lateral surface of the other two thoracic segments; a furrow down the center of each segment (on the dorsum); one pair of thoracic spiracles situated on the mesothorax just anterior to the insertion of the legs. Mesothorax and metathorax about equal in size.

Legs: Middle pair slightly the largest; coxa very stout, very thick at the base and tapering to about one-third the size at the distal extremity; numerous stout spines on

the anterior face and a few on the posterior; trochanter not quite three-fourths as long as coxa on its outer margin; inner margin about one-half as long as outer, distal extremity the largest; femur very slightly clavate, its longest side three-fourths as long as the coxa; distal extremity not quite as large as the distal extremity of the coxa; tibia two-thirds as long and two-thirds as large as femur, very slightly clavate; tarsus bearing one large claw. A whorl of spines at distal end of tibia; femur and half the length of trochanter with a double row of spines on ventral surface; one very long, slender spine on the trochanter, at apex on ventral surface.

Abdominal segments without chitinized plates, increasing in size (in full-grown larvæ) from base outward until reaching segment 4 and then gradually decreasing; a pair of spiracles on the anterior lateral aspect of each of the first 8 abdominal segments, so placed as to be visible from above; they are circular and much smaller than the thoracic spiracles; a large seta on the lateral aspect of each abdominal segment. The 9th segment bears the anal tube and the cerci.

Cerci slightly shorter than the longest abdominal segment, coriaceous, not motile; seen from above they are broad and slightly convex; beneath concave, tapering gradually toward their distal extremity; the two give the appearance of the letter "U"; the 8 large setæ symmetrically arranged with reference to the corresponding setæ on the other cercus; a row of small setæ on the inner margin of each cercus, the setæ arranged symmetrically with each other; the other portion of the cerci is densely covered with setæ.

Anal tube apparently as long as the cerci; from lateral aspect appearing cylindrical, apparently depressed dorsally, curving slightly downward at the tip; ventral margin of tip irregular in outline and slightly notched; from dorsal and ventral views the tube has the appearance of a truncated cone; ventrally there are numerous large setæ and a dense covering of small setæ; dorsal surface sparsely covered with setæ.

The larvæ are veritable little cannibals, for besides devouring the larvæ and pupæ of other insects they will, in confinement, destroy each other. They are very difficult to rear, and in no case could they be carried further than one or two molts. Hence, the length of the larval stage and the period between instars could not be ascertained. In confinement they feed readily upon small larvæ and the pupæ of other ground-beetles. It is almost impossible to make accurate field observations on them, as they are found at a depth of from a few inches to about 2 feet, depending upon the amount of moisture in the soil. Soon after a rain they will be found within a few inches of the surface, while during a dry period they go quite deep, apparently seeking moisture.

THE PUPA (fig. 8, *c*).

A detailed description of the pupa is given below:

From the lateral aspect: Oblong, increasing in thickness gradually toward the anterior extremity; prothorax depressed; antennæ directed dorsally, then ventrally, around the femora of the first two pairs of legs, the distal half resting between the elytra and the femora and tibiæ of the middle pair of legs. Front femora resting near the eye. Elytra and wings long and narrow and folded over the posterior pair of legs, the tarsi of which reach to the posterior margin of the sixth abdominal segment.

Ventral aspect: Head directed downward between the first two pairs of legs, not quite one-third length of entire pupa; mandibles closed but not overlapping; from the base of the mandibles to the tip about one-third as large as the portion of the head above them; labrum broad and short, and extending halfway down the mandibles;

maxillary palpi conical, long, parallel, and surpassing the mandibles by fully three-fourths their length; antennæ disappearing behind the fore and middle pairs of legs, coming into view again between the middle tibiæ and the elytra. Setæ showing but slightly until just before emergence of adult.

Legs: Fore and middle legs directed forward so that the maxillary palpi touch the anterior face of the anterior tibiæ near the distal extremity; anterior faces of the large, terminal, tibial spurs nearly touching; tarsi touching for almost the entire length, and lying between and above the tarsi of the middle legs, extending posteriorly. Middle tibiæ just posterior to front tibiæ, parallel to and very close to them. Claws divergent. Middle tarsi partly beneath the wings, their ventral surfaces facing. Hind tarsi extending beyond the wings and converging at the posterior margin of the sixth abdominal segment; ventral surfaces facing; claws divergent.

Elytra and wings completely covering the hind legs, with the exception of the tarsi, and almost touching beneath. No setæ on the ventral surface of the abdomen.

The pupal stage lasts from nine to ten days. When found in the fields the pupa is always inclosed in a little, oblong, earthen cell, about one-third of an inch long. Immediately after pupating it is a delicate creamy-white color. The eyes gradually turn darker, first becoming red and then black. Other parts of the body change to a darker yellow and then to a brownish color. The pupa is inclosed in a delicate, transparent, membranous covering, which splits down the dorsum when the adult emerges. Pupæ are found at a depth of from a few inches to about 2 feet, depending, apparently, on the amount of moisture in the soil at the time of pupation.

THE ADULT.

The adult (fig. 8, *d*, *g;* fig. 9) is of a dark, shiny-red color and is somewhat flattened and elongate. The wing covers are narrower than the thorax. The hinder part of the body articulates with the prothorax by means of a short peduncle. The fore legs are very broad and somewhat flattened, the tibiæ bearing several large teeth. The original description by Le Conte will probably not be out of place here:

Length 3¼ lines; breadth ⅞ line; dark rufous; front with three wide and deep longitudinal impressions, the middle ones abbreviated at the ends so as to form an oblong fovea; thorax oblong, rounded behind, but little convex, with longitudinal line deeply impressed; elytra narrower than the thorax, parallel, striate; striæ punctate, third interval with impressed points.

When it first issues from the pupal case the adult, or beetle, is pale yellow in color, gradually turning to the characteristic shiny red.

NUMBER OF GENERATIONS.

It seems that there are no well-defined broods or number of generations. The species breeds throughout the entire season, very small larvæ up to full-grown pupæ and adults being found at any time during the summer. The sexes were found in copula, June 14, 1909.

HIBERNATION.

The insects pass the winter in the adult stage. In November, 1908, careful search was made, during several days, in the cornfields for larvæ and pupæ, but none could be found, though there were plenty of adults present. This is not proof but a good indication that they pass the winter only as adults. Nothing, of course, is known of the eggs as they occur in the fields.

CHARACTER OF GROUND MOST LIABLE TO INFESTATION.

Larvæ, pupæ, and adults seem to confine themselves to low, swampy, peaty soils that remain moist the entire year. During a very dry

FIG. 9.—Structural characters of *Clivina impressifrons: a*, Ventral aspect of head and mouth parts: *b*, maxilla; *c*, parts of labium; *d*, fore leg; *e*, middle leg; *f*, hind leg. Much enlarged. (Original.)

period they have only a short distance to go below the surface to find plenty of moisture. Professor Webster states that he has observed them in great numbers, floating on the surface of the water in cornfields in Illinois, immediately after heavy rains.[a] Mr. W. C. Stromberg, Galesburg, Ill., states:[b]

> At another time a friend of mine turned up a nest of *Clivina impressifrons*. It was in early spring. They were clinging to the underside of a log which was very deeply

[a] Cir. 78, Bur. Ent., U. S. Dept. Agr. [b] Ent. News, vol. 4, p. 150, 1893.

embedded in black soil. In such situations it is rare to find Coleoptera except along the edges, but here there were Clivinas (closely crowded) on a space not larger than one's hand.

REARING EXPERIMENTS.

During the summer of 1906, when the writer's attention was first called to this insect, attempts were made to rear it in confinement. On June 15 several adults were collected and placed in a glass jar that had been previously filled with rich soil, and corn planted therein. No cover was placed on the jar, as the latter curved inward near the top, rendering this precaution unnecessary.

On August 18 the contents of the jar were carefully examined, but no eggs or larvæ could be found. There were 11 adults—not as many, however, as were placed in the jar on June 15. They had tunneled throughout the soil, but the corn had not been attacked. The beetles were still in good condition in December, though no eggs or larvæ could be found in the jar. Whether artificial conditions tend to prolong their lives or whether this is the average length of life could not be ascertained.

October 4, 1906, in a field near Richmond, Ind., a tight box 32 by 8 by 10 inches was let down vertically into the soil, a long box filled with sifted soil being used, so the beetles could go below the frost line if necessary. Some oats, corn, and wheat were planted in this box and about 24 adult beetles were placed inside, after which the box was covered with a closely woven wire screen. They began burrowing into the soil at once, very much after the manner of moles, parting and pushing aside the earth with their strong fore legs. On October 8, 42 more beetles were placed in the box. On June 5, 1907, this box was examined and one adult beetle was found near the top of the cage, just below the surface of the soil. Several others were found at and near the bottom, in their burrows, with their abdomens distended as if containing eggs. These last were apparently dead, though the tissues seemed to be in good condition, but some of them on being dissected were found to contain numbers of a little mite, determined by Mr. Nathan Banks as *Canestrinia* sp. No eggs, larvæ, or pupæ could be found. The fact that comparatively few beetles were present is probably due to their cannibalistic habits and to the presence of the mites, it being since learned that the beetles will devour each other when closely confined or where there is an insufficient food supply.

During the summer attempts were made to rear them in boxes containing soil from the fields where they had been found injuring corn, mixed with decaying wood and growing plants of different kinds, but without success.

In November a box 8 feet long, 3 feet deep, and 2 feet wide, made of tongue-and-grooved boards, was settled in the ground until the top was even with the surface. This was done on the farm of Mr. William G. Baker, near New Paris, Ohio. The box was then filled

with rich, peaty soil from the fields where the beetles had injured Mr. Baker's corn during the summer. About 40 adult beetles were placed in this box, which was then covered with closely woven wire gauze.

May 14, 1908, about 50 beetles were collected and placed in the box prepared the preceding November. During the summer the box was carefully examined, and while a few adult beetles were found there were no eggs, larvæ, or pupæ.

It appeared from these experiments that the insect could not be reared in confinement; so, during the months of July and August the cornfields that had been injured by the Clivina were examined every day, the soil being dug up from a few inches in depth to about 2 feet, and examined very closely. July 23 an adult was found that had just transformed, being still in the earthen pupal cell. This was probably among the first to issue this summer, as none could be found earlier, though patient, careful search had been made. Numbers of small Carabid larvæ were collected for rearing, but all either died or proved to be those of other species. The last week in July full-grown larvæ were found in the fields, which soon changed into pupæ. From this time on larvæ and pupæ could be easily found. Several attempts were made to rear larvæ through to the adults, but without success.

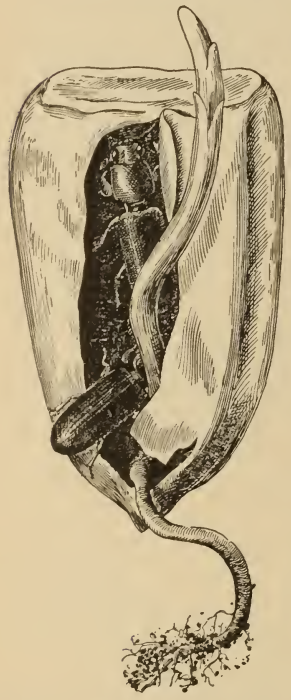

FIG. 10.—Slender seed-corn ground-beetles attacking a kernel of corn; the body of one protruding from the opening. This is the stage at which the major part of the injury is done. Much enlarged. (Original.)

Owing to the pressure of other duties, no further observations could be made on the species during the summer. However, the fields were examined carefully during November, but no larvæ or pupæ could be found. From the above it seems that they begin breeding in May or June and continue to do so through August, September, and probably October.

CHARACTER OF INJURY.

As soon as the corn is planted and starts to germinate the beetles begin to attack it. They usually commence at the germ, often eating the entire contents, leaving only the hull. Sometimes they begin their work before the grain starts to germinate, though it is rare to find them attacking kernels in this manner. As previously stated, they do not always finish a kernel, but as a rule sufficient injury is effected to prevent further growth. As many as five beetles have

been taken from a single kernel, some with part of their bodies protruding from the opening (fig. 10). Sometimes the young plant may push through the earth to the surface of the ground and then die, owing to the fact that the kernel has been destroyed and the root system has not developed sufficiently to support it. A plant with two leaves, that has the kernel entirely destroyed, is shown in figure 11.

RECORDS OF DEPREDATIONS.

EARLY RECORDS.

The first record of the plant-feeding habit of this species was in 1890,[a] from Whitley County, Indiana, where germinating seed corn

FIG. 11.—Work of the slender seed-corn ground-beetle. Reduced. (Original.)

was found to be attacked, the beetles starting their work at the germ. This corn was planted on black, swampy soil.

In 1900 Dr. S. A. Forbes[b] states: "This little ground-beetle, about a quarter of an inch long, * * * may receive mere mention as a beet insect, having once been seen by us in small numbers enlarging a small excavation on the petiole of a beet leaf. The same species had previously been seen burrowing freely into seed corn in the ground."

Five years later Prof. R. H. Pettitt, of the Michigan Agricultural College, reported the same character of injury to seed corn from the

[a] Insect Life, vol. 3, p. 159. [b] Bul. 60, Univ. Ill. Agr. Exp. Sta., p. 484.

vicinity of Trenton, Mich.,[a] having received material with the complaint that "the corn is badly eaten * * * ." These are the only instances on record of the depredations of this beetle previous to the outbreak in Ohio in 1906.

OUTBREAKS NEAR NEW PARIS, OHIO, IN 1906, 1907, AND 1908.

Some time during the first week of June, 1906, Mr. Wm. G. Baker, of New Paris, Ohio, reported that serious injury had been done by a little brown beetle in his cornfield, which was planted on black,

FIG. 12.—A cornfield near New Paris, Ohio, about the first week in July, 1906, showing results of depredations by the slender seed-corn ground-beetle. (From Webster.)

swampy land. Specimens sent to the writer at Richmond, Ind., proved to belong to this species. On the 15th of June a personal examination of the field was made, and the beetles found still working in the replants, as many as five being taken from one kernel. Twenty beetles were counted within a few inches of a single hill. The corn was planted in checks, with three to four kernels to a hill, and in many cases every kernel was destroyed. This field contained about 40 acres, only about 10 to 15 of which were injured, this being the lower part of the field, where the soil was black and peaty. In some places over a third of the corn, replants and all, was missing. Figure 12 shows the condition of the field a few weeks later.

[a] Bul. 233, Mich. St. Agr. Coll. Exp. Sta., p. 50, figs. 51, 52.

On June 7, 1907, Mr. Baker's field was examined, corn having again been planted in the same field. The first planting of the field was made during the first week in May, and it was replanted about May 20. The field was flooded by heavy rains after each planting. Mr. Baker thought the cool, wet weather was responsible for the poor stand, but as he had never examined into the cause, it is very probable that the ground-beetle exacted its usual toll. The field was then planted for the third time, about the middle of June. Very little of this last planting was injured. It seems that, as a rule, corn planted about the middle of June in this locality is not troubled to any great extent. Experimental plantings made in these fields during the summers of

FIG. 13.—Same field as in figure 12, about the first week of July, 1908, showing results of combined work of the slender seed-corn ground-beetle and cutworms. (Original.)

1906 and 1907 were rarely disturbed, though there were plenty of beetles abroad at the time. No other reason can be assigned for this, except that early in the season the beetles, being ordinarily carnivorous and finding animal food scarce, turn their attention to the palatable corn, whereas later, with animal food plentiful, they do not molest the corn.

May 14, 1908, Mr. Baker's fields were examined and the beetles found to be quite abundant, often as many as 30 to the square yard being found. Corn had not been planted up to this date, but the ground-beetle did considerable injury to this field later. Cutworms, probably *Agrotis ypsilon* Rott., and the beetles together destroyed at least 50 per cent of the corn on the lower part of the field, fully one-half of this being the work of the beetles. Figure 13 shows the condition of the field about the first week in July.

OUTBREAKS IN KANSAS.

Prof. F. M. Webster[a] states that in 1906 Prof. E. A. Popenoe, of Manhattan, Kans., called his attention to two instances where very serious injury had been done in cornfields in the southeastern part of the State, specimens having been sent with each report. Professor Webster stated also that there were numerous complaints in Kansas during that year of corn not germinating and of failures to get a stand on low, swampy land. The greater part of this injury was probably caused by the ground-beetle.

A great many reports of injury are never investigated, it usually being taken for granted that the depredations are caused by wireworms or some other well-known pest, while a large part of the injury is probably due to the ground-beetle.

REPELLENTS APPLIED TO SEED.

As it is a well-known fact that some odors are offensive to insects, a series of experiments was conducted in order to learn if the seed could be treated with some odorous preparation that would repel the attacks of this pest, and, at the same time, be cheap and easily applied. It was decided to use a liquid, as any form of powder or paste would increase the size of the kernel appreciably so that it would not readily pass through a planter. Several heavy oils having odors more or less repellent to insects were selected, as it was believed that these latter would remain longer in the soil after the treated seed was planted. Oils of lemon, cajeput, citronella, wormseed, and mustard, and carbolic acid were used. The oils were diluted to 10 per cent solutions in wood alcohol and applied at the rate of 3 ounces to a gallon of corn. Carbolic acid was diluted in water to a 3 per cent solution and applied at the same rate. The liquids were poured over the corn, which was then stirred vigorously so that each kernel would be completely coated. In planting the checks, all the corn was removed from the planter and the latter filled again with fresh, untreated seed.

EXPERIMENTS IN 1908.

Mr. Wm. G. Baker, near New Paris, Ohio, whose fields had been so badly affected, consented to have the experiments on his farm. Each plat consisted of four rows across his field in the worst infested area. The beetles were very abundant, as many as 30 to the square yard often being found. The numbers of the several plats and the oils with which the seed in each was treated are as follows:

Plat 1, oil of lemon; plat 2, oil of cajeput; plat 2*a*, check (not treated); plat 3, oil of citronella; plat 4, oil of wormseed; plat 4*a*,

[a] Cir. 78, Bur. Ent., U. S. Dept. Agr., 1906, p. 5.

check (not treated); plat 5, oil of mustard; plat 6, carbolic acid. The plats were planted May 21, 1908.

All plats were examined on June 1, 2, and 3, 1908. Every hill that contained no live plants, or that had only one plant, was dug up and examined carefully. Two hundred hills in both the experimental and check plats were inspected. The results are summed up briefly in the following table:

TABLE I.—*Results of experiments in treating seed-corn with repellent oils to ward off attacks of the slender seed-corn ground-beetle.*

Plat No.	Number hills examined.	Destroyed by Clivina.			Destroyed by other pests.			Per cent affected by Clivina.	Per cent affected by other pests.
		Number hills entirely destroyed.	Number hills with only 1 plant.	Total.	Number hills entirely destroyed.	Number hills with only 1 plant.	Total.		
1	200	11	8	19	25	27	52	9.5	26
2	200	8	11	19	15	42	57	9.5	28.5
2a	200	11	21	32	28	30	58	16	29
3	200	7	11	18	21	35	56	9	28
4	200	12	16	28	36	49	85	14	42
4a	200	10	20	30	21	38	59	15	29.5
5	[a] 200								
6	200	10	12	22	21	20	49	11	24.5

[a] In plat 5, a very large percentage of the seed did not germinate and it is to be inferred that the kernels were injured by the oil, therefore this plat was not included in the table.

No attempt was made to ascertain the number of hills destroyed by each individual pest other than the Clivina. A cutworm, probably *Agrotis ypsilon*, caused a large amount of injury. Wireworms and the seed-corn maggot were also responsible for a part of the trouble. The oil of wormseed probably injured the kernels, as a much larger number of plants in plat 4 were missing than in some of the others.

EXPERIMENTS IN 1909.

After looking over the results of experiments conducted during the year 1908 it was decided to use the oils of cajeput, citronella, and lemon, as these promised the best results. Two small plats (Nos. 5 and 6) were planted later than the others, one (No. 6) with and the other (No. 5) without fertilizer, the fertilizer being placed directly on the corn.

The plats were in the same place as those of the year 1908, and conditions were the same as regards the size of the plats and the quantities of materials used. The treatments given the several plats were as follows: Plat 1, oil of cajeput; plat 2, oil of citronella; plat 3, oil of lemon; plat 4, check (not treated); plat 5, 95 hills planted June 2 (unfertilized); plat 6, 93 hills planted June 2 (fertilized). Plats 1 to 4 were planted May 22, 1909.

Plats 1, 2, 3, and 4 were examined June 5 and 7, and plats 5 and 6 examined June 14. The same plan that was used last year was adopted. The following table gives a brief summary of the results:

TABLE II.—*Results of experiments in the treatment of seed corn to ward off attacks of the slender seed-corn ground-beetle.*

Plat No.	Number hills examined.	Destroyed by Clivina.		Total.	Destroyed by other pests.		Total.	Per cent affected by Clivina.	Per cent affected by other pests.
		Number hills entirely destroyed.	Number hills with only 1 plant.		Number hills entirely destroyed.	Number hills with only 1 plant.			
1	200	8	10	18	.....	46	46	9	23
2	200	20	14	34	.....	24	24	17	12
3	200	17	18	35	.....	24	24	17.5	12
4	200	5	16	21	.....	13	13	10.5	6.5
5	95	5	7	12	3	9	12	12.6	12.6
6	93	5	11	16	8	10	18	17.4	19.3

The last two plats (5 and 6) should not have been planted until about June 10. Normal results could not be expected from such small plantings, as the beetles were no longer working on the larger corn; consequently the percentage of beetles to the hill in these plats must necessarily have been much larger than in the early plantings, when the whole field was planted at once.

In plats 2 and 3 it will be noted that 20 and 17, respectively, are the number of hills mentioned as being entirely destroyed by the Clivina. In both of these plats were found hills that contained no seed, and, as no other cause for this could be assigned, the whole was charged up to the Clivina.

Three checks near the plats were examined, counts being made of the number of hills with only one plant. None of these hills was dug up, as Mr. Baker had replanted the corn, and, of course, this would have interfered with the results.

The following table gives the results of counts in these check areas:

TABLE III.—*Results of examination of check areas of corn as to injury from the slender seed-corn ground-beetle.*

Check number.	Number hills examined.	Number hills with plants entirely missing.	Number hills with only 1 plant.	Total per cent of hills affected.
1	200	24	44	34
2	200	20	36	28
3	200	17	46	31.5

WEATHER CONDITIONS.

The facts concerning the temperature and moisture of the periods over which the experiments, described above, extended were obtained from Mr. Walter Vossler, the local observer at Richmond, Ind. The conditions prevailing at Richmond were very nearly the same as those at Mr. Baker's farm, which is only 8 miles away.

The following table gives the maximum, minimum, and mean temperatures and the rainfall in inches for the months of April, May, and June in 1908 and 1909:

TABLE IV.—*Temperature and rainfall conditions at Richmond, Ind., April, May, and June, 1908 and 1909.*

Month.	Maximum.	Minimum.	Mean.	Rainfall.	Month.	Maximum.	Minimum.	Mean.	Rainfall.
1908.				*Inches.*	1909.				*Inches.*
April	80	24	52	3.76	April	82	20	51	4.68
May	92	29	60	4.97	May	83	32	57	5.37
June	93	39	66	2.69	June	88	47	67	5.74

NATURAL ENEMIES.

A small mite (*Canestrinia* sp.) has been found in great numbers in the abdomen of the adult beetles. As cited on page 19, this mite apparently destroys the beetles, though nothing definite has yet been learned as to the extent of the destruction from this source.

PREVENTIVE MEASURES.

Since the beetles confine themselves to low, swampy land, it would appear at first glance that the remedy is very simple—cease planting such land to corn. However, to a man whose farm consists chiefly of such land, this would seem very poor advice. In the vicinity of Richmond, Ind., corn planted about the middle of June is but little disturbed. From the foregoing it would appear that the greater part of the damage may be avoided by late plantings. This would seem to offer some relief. The class of soil mentioned above usually remains wet and cold until quite late in the spring, but even in case the spring should be a dry one, the extra time could be very well employed in preparing a good seed-bed.

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